FOOD AND EFFICIENCY.

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One of the triumphs of modern chemistry has been achieved in the field of living organisms. Biochemistry represents the particular line of research which has thus enriched our knowledge of life. Long ago scientific men were struck with the similarity of the action of the human organism and of the steam engine. In the one case food is placed in the stomach and heat and energy are developed; in the other case fuel is placed in the furnace and heat and energy are developed. Engineers were not slow to notice the enormous efficiency of the human engine as compared with that made of steel and iron. A pound of fuel fed to a grown man will develop apparently many times as much energy as a pound of coal fed to the boiler of an engine. In other words the mechanism of the body, in so far as the use of fuel is concerned, is a much more finished machine than that built by man.

As our knowledge of living phenomena became more definite it was seen that the human body is a chemical laboratory which in its equipment for efficiency far outclasses the most elaborate structures of the universities and industrial combinations. While it is cheaper to operate it is very much more efficient in service. The peculiarity of the human laboratory is that it extends to every part of the structure. While there are certain rooms in the human laboratory in which particular functions take place, the general utilization of the fuel is spread to every particle composing the human

machine. The mouth, the lungs, the stomach, the heart, the intestines, the kidneys, all perform particular functions, but every portion of the human anatomy takes part in the general chemical processes. A steam engine to be efficient must be well made, of strong material, properly balanced and thoroughly lubricated. The motive force in such an engine will do its maximum amount of work. The efficiency of the human body likewise depends first upon its structure, that all parts should be evenly balanced and so adjusted as to work harmoniously as a unit. Without a perfect working laboratory like this it is useless to seek for the highest degree of individual efficiency. With such a working organism it is necessary only by practice to acquire the skill, in other words to become educated, in order to secure the greatest efficiency possible.

As Ruskin has well said, "The first duty of a man is to be a good animal." This means that he is to have a well-proportioned body, of a proper size, free of fault and disease, and properly developed by exercise to put forth as occasion demands a maximum degree of energy. In studying the factors which bring about the building of such a laboratory and its operation we are struck with the fact that the fuel, that is, the food, out of which the body is built should be of a proper kind, properly balanced and used in proper quantities. From the chemical point of view food is that which, taken into the body, builds tissue, restores waste and supplies heat and energy. The terms "heat" and "energy" may be used synonymously. Without heat the energy which is manifested in the living body could not be developed. Of course there is a distinction between heat and energy. Energy is work, exertion, effort. Heat is merely a certain condition of temperature. The exact knowledge of the relations of heat to the energy

of the body has been obtained by the chemist by means of an instrument known as a calorimeter.

The human organism existing in complete repose, as in peaceful sleep, exerts the minimum degree of energy and thus requires the minimum amount of fuel. If it were possible for man to hibernate, as is the case of many animals, he would require the least quantity of fuel to maintain the energy of his body. Perfect repose and protection, in so far as possible in a low temperature, favor the economy of fuel. In the case of man a condition of peaceful slumber at a temperature of about seventy degrees affords an environment of least expenditure. The amount of fuel required in such a case is called basal and represents merely that which maintains the functioning of the body in a state of complete repose. In the case of a man of average weight, say a hundred and fifty pounds, in repose, the amount of fuel required for twenty-four hours is approximately eighty calories per hour. On the contrary, during the waking period when he is engaged in ordinary activities he would require a hundred and twenty calories per hour. It has been estimated by some investigators that the ordinary individual in such circumstances, spending seven or eight hours in sleep, about the same length of time in recreation or eating, and eight hours at medium active labor, would require for the twenty-four hours less than three thousand calories.

A calorie is the amount of heat required to raise a kilogram of water at an initial temperature of about twenty degrees to a temperature of twenty-one degrees Centigrade. The specific problem to which attention is called in this paper is the relation between food and efficiency as measured by the power of the individual to do things. It is evident that the efficient nation must

be made up of efficient individuals. Why is it that so many men and women reach maturity unfit physically, and therefore to a certain degree mentally and morally, to discharge the active duties of citizenship? An inquiry into the extent of this unfitness will show the extent of national inefficiency.

Perhaps there is no better basis for this comparison than the experience in military enlistment. I by no means claim that a citizen is unfit because he is not capable of bearing arms. I call attention, however, to the fact that such a citizen does not measure up to the standard of efficiency which nations in time of peace require of their soldiers. It takes a good animal, in the Ruskin sense, to be a soldier, in the same way as it requires a good animal to be an efficient citizen in any line of duty which he may choose to follow. The records of enlistments in times of peace show a remarkable percentage of inefficient male citizens. We may reasonably suppose that inefficient female citizens exist in an equal number.

Percentage of Candidates for the Army and Navy Rejected by Reason of Physical Imperfections.

Through the courtesy of the Navy and War Departments, I have obtained the following data relating to the physical inefficiency of volunteers for the respective services. In the Navy Department the data are as follows:

For the fiscal year 1912:	
Applicants for enlistment	73,364
Applicants rejected for physical reasons	36,999
Percentage of rejections	50.5 per cent.
For the fiscal year 1913:	
Applicants for enlistment	75,457
Applicants rejected for physical reasons	39,070
Percentage of rejections	51.5 per cent.

For the fiscal year 1914:

Applicants for enlistment	88,943	
Applicants rejected for physical reasons	47,240	
Percentage of rejections	52.5	per cent.

For the War Department the data are as follows:

For the fiscal year 1915:

Applicants for enlistment	168,842	
Applicants rejected for physical reasons	84,167	
Percentage of rejections	68	per cent.

While, of course, in time of peace examinations of a physical character are far more rigorous than in time of war, we cannot refrain from expressing a grave doubt as to the efficiency of our male citizens of ages suitable for military service, when such enormous numbers of them are rejected as unfit to serve either in the Army or Navy.

I do not have access at the present moment to the data of European countries relating to this matter. We only know that in time of peace very large numbers of their citizens are found unfit to serve under the colors. The number now is doubtless very much less when every one who is capable even of partial effort is gladly welcomed to the trenches.

Relation of Inefficiency to Food.

What relation may we be able to trace between this remarkable exhibit of inefficiency and the character of the food? On this point there are no definite data. In rejecting recruits on account of physical defect no general cause of this defectiveness is usually stated. We have, therefore, to trace it from our general knowledge of the environment in which our people are brought up. First of all, we know that in the human infant any imperfection in the food makes itself felt in a most marked way. The fearful mortality among

infants under the age of one year, when traced to the causes as stated in the death reports from areas where vital statistics are registered, indicates that a very large majority of all deaths is caused directly or indirectly by improper food. It is reasonable to infer that of the infants who do not die a very large proportion enter childhood with the handicap of infirmity caused by improper food.

During childhood the errors of diet continue their work of destruction. Children are not fed in a manner to develop all the tissues of the body. The teeth and bones, especially, are apt to be inferior because of the character of food which is offered to our children. Modern refinement, so-called, has seen fit to rob many of our national foods of the vitalizing principles most necessary to health and proper growth. Decorticated cereals, peeled apples and potatoes, and refined foods of all descriptions, especially sugars, candies, cakes, ice creams and so on, not to forget chewing gum, are the common diet of most of the children in the country. The failure to develop good, sound teeth on such a diet and the bad influence of sugar and candy on teeth when they are developed have produced that terrible condition in our children of defective mouths which has been revealed in every case where dental inspection of school children has been established. In the city of Cincinnati, where a rigid inspection of the teeth of the school children has recently been inaugurated, the enormous percentage of ninety-five has been recorded of defective teeth. What can we expect from the efficiency of the grownup individual who in childhood completes his growth with such a handicap?

Inasmuch as good teeth are necessary to health and efficiency, and since it is certain that poor teeth are largely the result of an improper diet, the importance

of proper nutrition of infants and children cannot be overestimated. Results which have come from improving the teeth in our public schools are strongly corroborative of my theory that individual and national inefficiency is largely the result of improper diet in infancy and childhood. The number of documents which could be cited on this particular is very great and they will be found in the library connected with the Bureau of Education. A few of these articles may be cited particularly in this connection. In the proceedings of the Board of Education of Cleveland, for February 27. 1911, there is a most valuable report on the oral-hygiene educational campaign in that city. The records of this document take up particularly individual cases and trace the benefits derived from improving the condition of the teeth. A single citation from this document is typical:

Carrie Mangino, age thirteen years, exhibited on examination by the dental clinic a very imperfect mouth. The teacher reported the case as almost hopeless; nevertheless, an attempt was made to remedy the difficulties. It was necessary to administer an anæsthetic in order to perform the operations necessary to put the mouth in good order. As a result of this treatment the eye strain was relieved, and the good results in scholarship and deportment are contrasted with the poor scholarship and deportment previous to the operation in the following table:

Report Before Treatment of the Mouth.		*Report After Treatment of the Mouth.*	
Scholarship	poor	Scholarship	improved
Attention	poor	Attention	good
Effort	fair	Effort	good
Behavior	irritable	Behavior	excellent
Appearance	poor	Appearance	excellent
Manner	nervous	Manner	composed

The *Journal of Educational Psychology* contains an interesting article for the December number, 1913, on the effect of dental treatment upon the physical and mental efficiency of school children. The conclusion found on page 578 of the *Journal* cited shows that a decided lead was taken by the children whose dental troubles had been remedied by the dental clinic. The improvement in appearance and deportment was marked and in the educational test a similar improvement was secured. The National Mouth Hygiene Association has issued a report on the Scientific Experiments Conducted in the Cleveland Public Schools for the Purpose of Ascertaining the Value of Healthy Conditions of the Mouth. This publication contains extensive data showing how the betterment of dental conditions improved the scholarship, health and deportment of the children who were treated. In summing up the results of these experiments Dr. W. G. Ebersole states:

"The question of mouth hygiene, as presented in connection with the Educational Campaign of the National Mouth Hygiene Association, is an economic or educational one, and the installation of dental inspection and instruction in the schools means a tremendous saving to the states, or to the municipalities, as is shown in the report made to the Board of Education, and the writer believes that the Boards of Education throughout the country should install dental inspection and instruction, and then spend part of their savings in increasing the salaries and bettering the environments of the public-school teaching profession."

If this condition is due chiefly to the character of the food, and of this there is no doubt, the general effect upon the other organs of the body is easily predicated. Our children are coming to maturity not only with improper diet, but also with inefficient grinding apparatus to prepare their food for digestion. The efficiency of

the nation is rapidly and extensively undermined by failure to control the diet of the child. If we should return as chemists to the data which our investigations have brought to light and base our system of feeding upon these results of chemical studies, we would soon see the danger of feeding white-flour products, sugars, candies and cakes to our children. We would find that these foods either contain no tissue-building materials at all, which is true of sugar and candy, or that the tissue-building materials in the other foods have been so diminished by processes of milling, bolting, peeling and other refining methods, as to totally unfit them for nutritional purposes.

We are striking at the very vitality of our country when we neglect this fundamental principle of child welfare. While I would not maintain in this thesis that improper diet is the sole cause of individual and therefore of national inefficiency, I do emphasize with all the power at my command the dominant rôle which good food plays in producing the efficient citizen. If, instead of fifty or sixty per cent. of our adult males being unfit to serve their country in the army, that percentage could be cut to ten or even to five, and this goal is not at all unattainable if we recognize as we should the rôle of diet in health, how greatly would our national efficiency be improved!

Not only does an imperfect diet thus undermine the general constitution and produce a race of weaklings, but at the same time it causes, either directly or indirectly, a great many painful and even fatal diseases. It is well known that in those nations where the food supply is somewhat restricted, and especially where the supply of protein in the form of meat is curtailed either by lack of supply or high cost, there is a tendency to develop a race of smaller stature in contrast

to those nations of generous diet and especially of active outdoor life. The nations of southern Europe, where the diet is less generous, are smaller in stature than those of northern Europe, and in the newer countries, such as the Americas and Australia and its adjacent islands, the human stature is the largest of any other part of the world. In the War of Secession, 1861–1865, it was found that the soldiers from the state of Indiana were larger in stature than those from any other of the states where records were kept. This is undoubtedly due to the method of life in that state, which was at that time peculiarly an agricultural state, with no large cities, where the people lived in the open, ate freely of the generous diet which the soil provided, and thus, by living close to nature, were better nourished and better developed than the citizens of other states. The remarkable strides which Indiana has made in its development, in its contributions to the military service of the country, in its multitude of poets and novelists, politicians and vice-presidents, indicate that upon the whole it is the most efficient state in the Union. In such a community nutritional diseases are reduced to a minimum.

What are some of the diseases which an improper diet tends to promote if not directly cause? Specifically, we ascribe rheumatism, gout, scurvy, beri-beri and pellagra to an improper diet. The investigations of the public-health service have shown that where a diet is unbalanced by increasing its carbohydrates and diminishing its protein, pellagra is apt to develop. In Japan it has been demonstrated that the dreadful nutritional disease beri-beri has been produced by a diet consisting largely of polished rice. When the rice is eaten with its bran pellagra is not developed. When rice bran is administered to pellagrins the disease is

arrested and cured. We must cease eating brands and eat bran.

We must not stop in our study of efficiency with the diseases which seem to be directly caused by an improper diet. It is a well-established principle that anything which diminishes the vitality of the body tends to make it more sensitive to the inroads of disease. Thus tuberculosis is developed more readily in persons of low vitality than in those of high vitality. The efficiency of diet in the control of tuberculosis is an index of what might be expected if the generous diet were used as a prophylactic. The outdoor life, fresh, simple foods, especially milk, whole wheat bread, fruits and fresh eggs, are the only remedies known for tuberculosis. They would be still more efficient if used before the onset of the disease. In fact, we may not be able to measure, even with a vivid imagination, the benefits to the efficiency of the nation which would come from a general supervision of its diet in the interests of simplicity and completeness. Not only is an abundance of foods desirable, but also a balancing of the diet. Again the chemist comes forward to solve this problem. He it is who tells the nutritional expert the elements which are found in his food and the proper method of mingling them so that they shall do most efficient service. The diet which supplies all the wants of the body and has little left over, except the necessary refuse, is ideal. On the other hand, if one is compelled to eat a large quantity of food, more than is necessary for his sustenance, in order to get the proper quantity of any one element in that food, he burdens his system with a large quantity of matter which must be disposed of in some way. Where there is an undue ingestion of fats and carbohydrates nature utilizes what she needs and stores the rest up as adipose tissue on the one

hand, or as glycogen on the other. The human animal may be likened to a pelican in its capacity for storing excess of fats and carbohydrates, but it has no pouch in which to put away an excess of protein. Thus this element of food which is so important in producing efficiency must not be used in excess. There is only one way in which nature can rid herself of an excess of protein—that is by overworking the liver and kidneys and excreting the protein principally as urea. Thus the labor of disposing of an excess of protein is greater than in disposing of an excess of fats or carbohydrates.

A short time ago I had the pleasure of visiting the Agricultural College of Iowa, at Ames. This institution has done wonderful work in the study of the diet of farm animals and in teaching the farmers of Iowa economical methods of feeding farm animals for various purposes, especially for the market. Interested in all problems of this kind I asked the professor of animal husbandry to show me the feeding experiments which they were conducting. We came soon to a pen in which there were a dozen or more young pigs, apparently eight or ten weeks old. They were sorry-looking animals, cadaverous in expression, void of hair on many parts of their bodies, and in general presenting a most unhappy condition. I said to him, "These pigs have mange, have they not?" He answered, "No, they have corn." Amazed somewhat at his reply I said that I thought corn was an excellent food for a hog. He said, "It is, but it is a bad food for a pig. These pigs have had nothing but corn in some shape or other since they were taken from their mother at a very tender age. Many of them have died, and others will die unless we change their diet."

Investigations, as is well known, have shown that zein, which is the principal protein of Indian corn, does

not promote growth when fed alone, and this experiment showed that even when fed in connection with the other proteins of the maize kernel it would not promote growth in young animals. In the degradation of zein by enzymic action in the intestines the amino-acids which are formed do not contain those fundamental products of nitrogenous character which favor the growth of young tissues. If pigs are fed Indian corn together with milk, both vigorously promote growth. Other experiments have shown that if zein be fed in connection with the amino-acid tryptophane, growth is also promoted. Other investigations have shown that a mono-diet, except milk, is usually incapable of properly developing body growth to maturity.

The practical lesson of an investigation of this kind consists in the fact that it is not enough to select food products with a certain proportion of protein, but that protein must be of a kind which, when reduced to amino-acids, will provide the necessary building stones of the body. Many food products contain proteins that are well adapted to promote growth, even alone. This is particularly true of the proteins of milk, and to a less degree of the proteins of wheat. Animals may live, grow and flourish when fed milk alone. They will also live, grow and flourish for a considerable time when fed whole wheat alone. By reason of animal idiosyncrasies it is not wise that the protein element of the diet be confined to a single source. The changing of one protein food for another not only promotes palatability by ministering to taste, but also favors safety by furnishing a variety of nitrogenous building materials.

Another development in connection with this matter consists in the idea of Funk, that certain parts of vegetable substances, particularly the external coat-

ings, as the bran of rice and wheat, contain an element which is very activating in growth and nutrition but minute in amount, the nature of which has not been fully established. Funk gave to this practically unknown principle the name of vitamin. It has long been a common observation among farmers that stable manure promotes growth to a degree much greater than would be expected from the analysis of this product. Stable manure contains a vitamin so far as vegetable growth is concerned. Milk, the bran of wheat and the bran of rice, are samples of animal and vegetable diets which contain a similar body. A dairyman will pay almost as much for a ton of bran as he does for a ton of cottonseed meal, although the cottonseed meal contains twice as much of the protein element as the bran. The bran evidently promotes the flow of milk and the health and vitality of the cow to a degree not warranted by a perusal of the analytical data of its composition.

In the practical application of this principle to nutrition we acknowledge the advisability of a varied diet. This does not mean that one should eat everything at every meal, but it does mean that the single article of food should not be continued too long, but should be substituted frequently by different simple foods in a state of natural composition when possible.

Science, which leads to knowledge, is the great promoter of human advancement and necessarily of human efficiency and there is no way in which its munificent effects are better manifested than in the studies which relate to the vital activities. A few years ago a formless mass of matter was not considered as of much importance. If it were a crystalline body its nature could easily be determined and studied. But the very basis of living tissue is amorphousness. We have to

deal here with that class of bodies long known but only lately appreciated—colloids. Biochemistry therefore does not consist alone in the story of the fate of the food in the body and the building of the tissues, but in addition to this in the actions and interactions of large masses of amorphous material which compose the principal tissues of the human body. The laws that govern colloids, therefore, are an integral part of biochemistry. Fortunately, in the many vogues of chemistry the colloids have not been neglected. Forty years ago organic chemistry was the favorite branch of study, and wonderful progress has been made in our knowledge of chemistry through the practice of organic investigations. Following this came the era of physical chemistry, also pregnant with great results for humanity. Then came, in its turn, as a favorite of fortune the study of the chemistry of living bodies, and this in turn developed the importance of the colloid as a fundamental condition of organic life. In all these fields chemistry has given notable contributions.

We are now on the threshold of a new movement, namely, the conservation of life and efficiency. In this movement chemistry has taken and will continue to take a leading part. Through the schools, the newspapers, the magazines, the rostrums and the pulpits of the country, the doctrine of efficiency will be preached as a concept of patriotism. We shall see, as a result of the application of these studies, a better race than ever before. We will see the lives of infants saved, the growth of children promoted, and the efficiency of the adult established.

The proper nutrition of a nation is necessary not only to develop its highest efficiency, but in times of stress, and especially war, the feeding of the army is a matter of the utmost consequence. Napoleon said:

"Soldiers fight on their bellies." It is useless to provide munitions of the highest type, rifles and cannons of the best make and the largest caliber, if at the same time the soldier who is to use these things is starving.

In the great war game which is now going on there is more discussion of the probable lack of food than there is of the actual lack of munitions. The great struggle will probably not be decided on any battlefield either on land or sea. Those nations which are best fed, and whose food supply is best assured, in the end are likely to prove the victors. There is no horror of a battlefield which is at all comparable with the horrors of famine. A nation can withstand successfully the demands of a faction that would make peace honorably or dishonorably, but no nation can withstand a universal cry for food. No government could persist which would, by striving to prolong a state of war, starve a whole nation. The great battle and the final victory will therefore not be fought in Europe, nor upon the seas, but in the wheat fields and maize fields and pastures and grazing lands of the whole world. Germany has shown a remarkable degree of practical wisdom in not only controlling the traffic in foods, but in educating the people to the greatest economy in their use. The tenets of biological and physiological chemistry have been put to a practical test of efficiency in the instructions which have been given the whole German people regarding the fundamental principles of proper nutrition. It is not wholly the abundance of food; it is the balancing and scientific use of food which best nourishes a nation. In fact, a superabundance of food may not be a blessing, but a threat, to a nation. My own observation leads me to believe that among the ordinarily well-to-do people of the United States excess in the consumption of food is a greater threat to

our health and long life than a shortage of the food supply would be.

What is needed particularly in the propaganda for scientific nutrition is less theory and more fact. The country is flooded with theories of nutrition. Hundreds of diet cards are constructed from various points of view as a proper adjustment of foods to physical wants. The fact of the case is that scientific nutrition of man is still in its infancy in this country, and if we were engaged in a world struggle and it were necessary to economize and husband our food supply and utilize it in a most efficient manner, we could not, as Germany has done, send into all parts of the country teachers of diet armed and equipped with a scientific training. In fact, in so far as the propaganda for food efficiency is concerned it is rather in the hands of the unskilled, and sometimes the conscienceless, than in the hands of trained nutritional chemists. Our newspapers and magazines have been flooded with advertisements of the cure and prevention of disease by different kinds of food which have been essentially of a nostrum, patent-medicine character, and which have resulted in some cases in fraud orders issued against the propagandists. The medical profession, I am sorry to say, has been very imperfectly trained along these lines, and the prescriptions for foods given by physicians would be laughable if they were not so pathetic and dangerous.

As a means to our highest efficiency the teaching of the correct principles of nutrition, based upon the facts of actual scientific demonstration, is essential. First, it must be done in the higher institutions of learning. Gradually must it reach even the primary schools. If we are to assume a position in the ranks of nations which will command respect, and if necessary fear, the

efficiency of our people must be brought to the maximum in order that the efficiency of our national defense may reach the same position. I speak particularly at the present time of the efficiency in the military service, but only because of the circumstances of the present time. That which makes for the highest efficiency in military service also affords the foundation for the highest accomplishments in all lines of human endeavor. A properly adjusted diet from infancy to old age will give to each one of our citizens, and hence to the nation, the greatest ability to make progress in all the arts of peace as well as to stand the shock of all the ravages of war.